

# Interim Report of Elasticity Values Subgroup

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# Tasks

1. Translate GTAP constant elasticity of land transformation into own and cross price supply elasticities and calculate implied elasticities for important AEZ's (U.S. and Brazil at a minimum).
2. Determine “reasonable” estimates of own and cross price elasticities
3. Compare range of acceptable values to actual values used in GTAP
4. Develop procedures and estimate the ratio of the productivity of new land to old land (CARB's elasticity of crop yields with respect to area expansion)

# CET Supply Function

$$Q_{land} = \alpha \left[ \sum_{i=p,f,c} \beta_i Q_i^\rho \right]^{1/\rho}$$

Elasticity of land transformation

$$\sigma = \frac{1}{1-\rho} < 0$$

# Price Elasticity

## Own price elasticities of land use

$\mathcal{E}_{crop,crop} \equiv$  % change in crop land due to a 1% change in crop returns

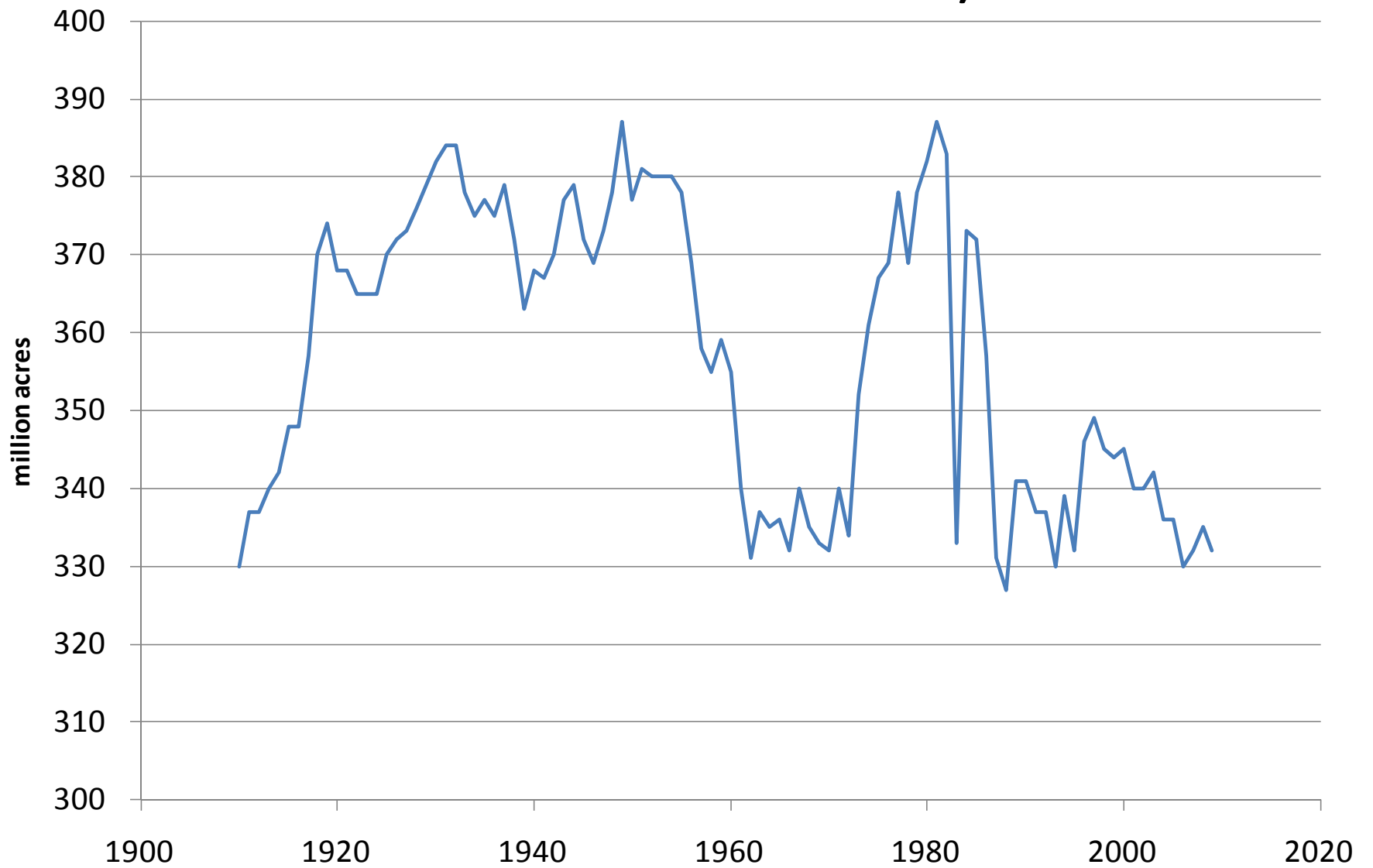
$\mathcal{E}_{pasture,pasture} \equiv$  % change in pasture land due to a 1% change in pasture returns

$\mathcal{E}_{forest,forest} \equiv$  % change in pasture land due to a 1% change in forest returns

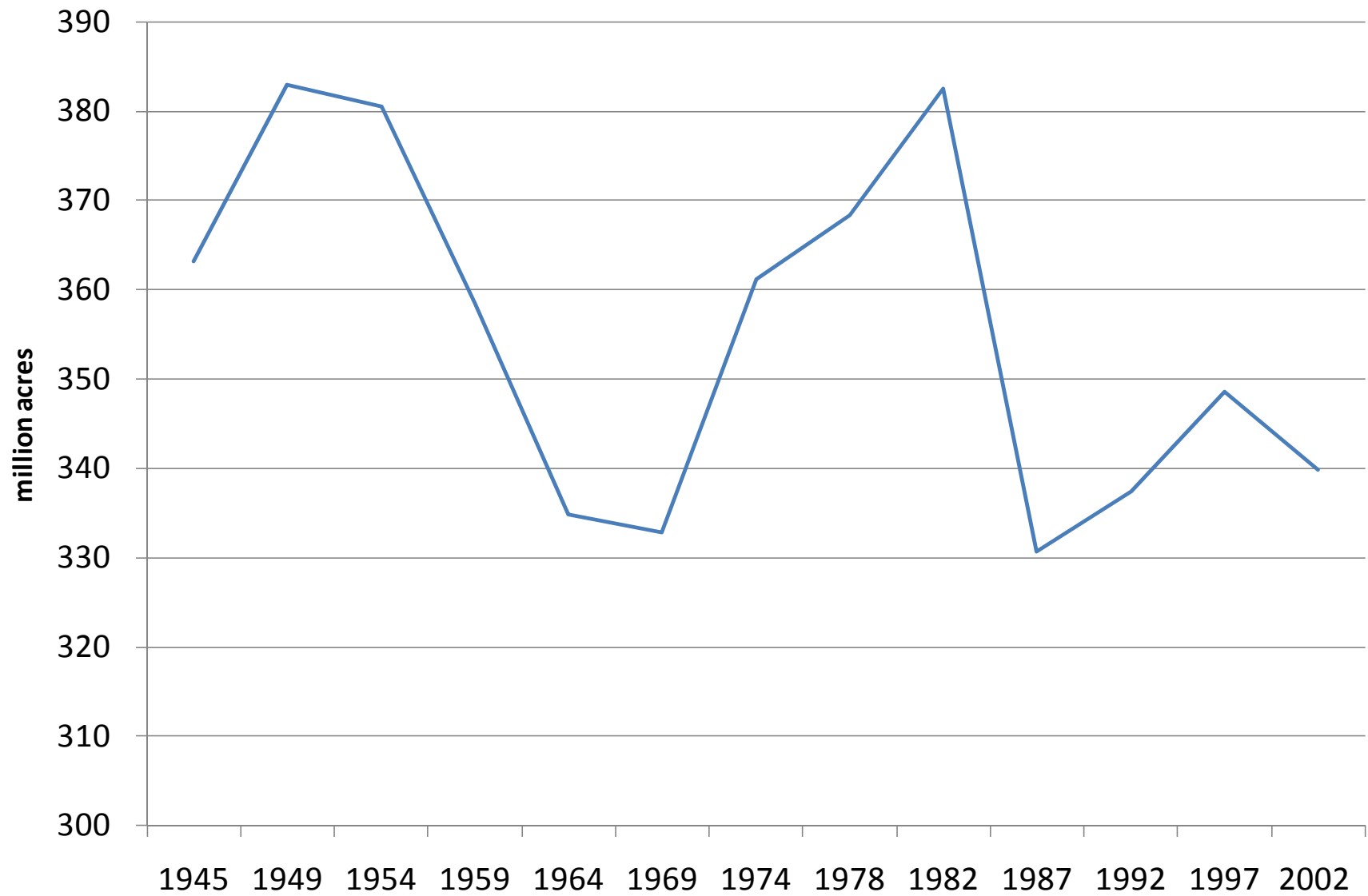
# Land Use Elasticity Logic

- Purpose of using GTAP is to measure the change in land use due to a crop price increase
- The more cropland-constrained a region is, the less a region will readily (one to five years) respond to crop price signals
  - Need to know the amount of idle cropland available

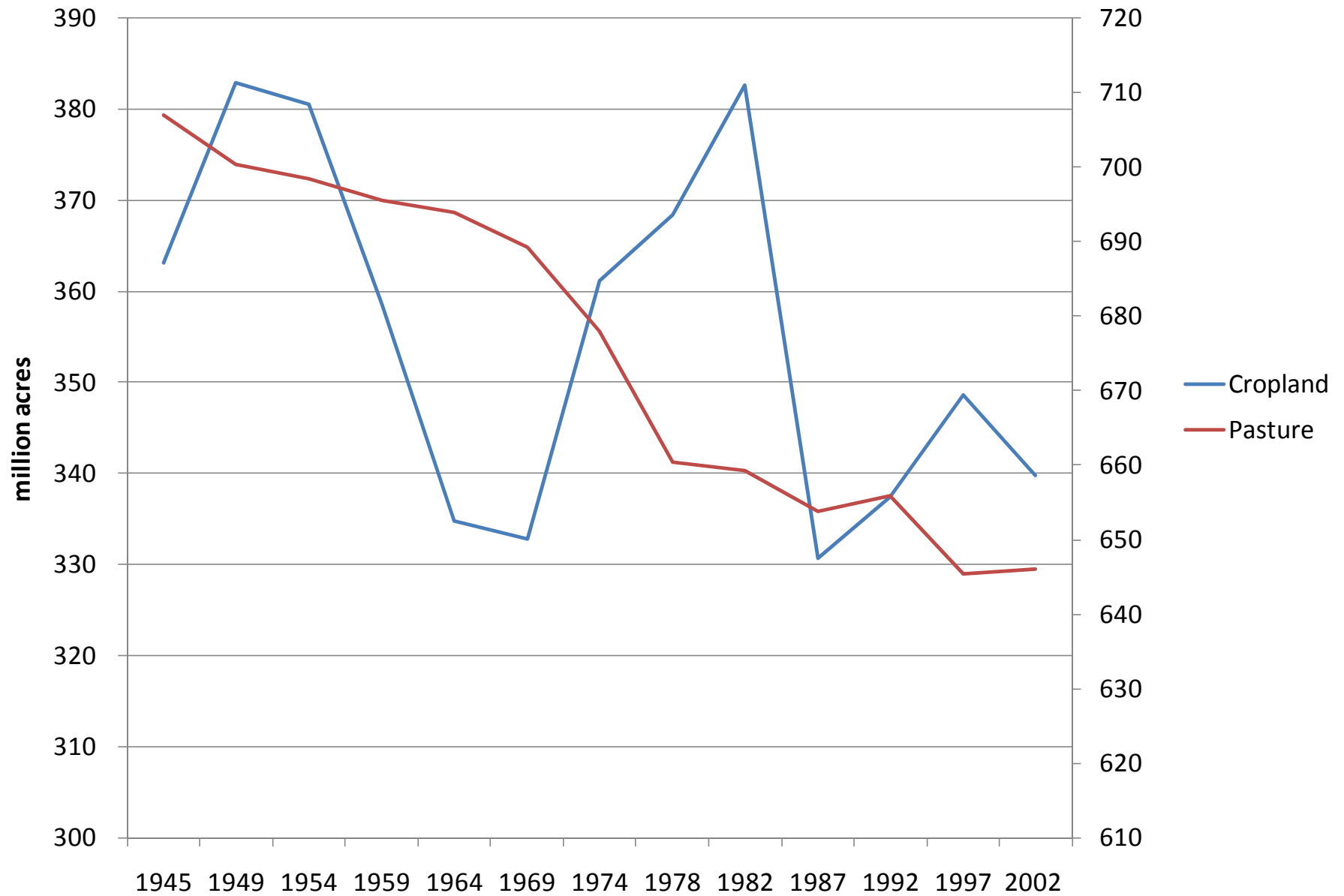
## U.S. Crop Acres Since 1910 (Source: USDA-ERS to 2006 and calculated 2007 to 2009)



## U.S. Crop Acres Since 1945

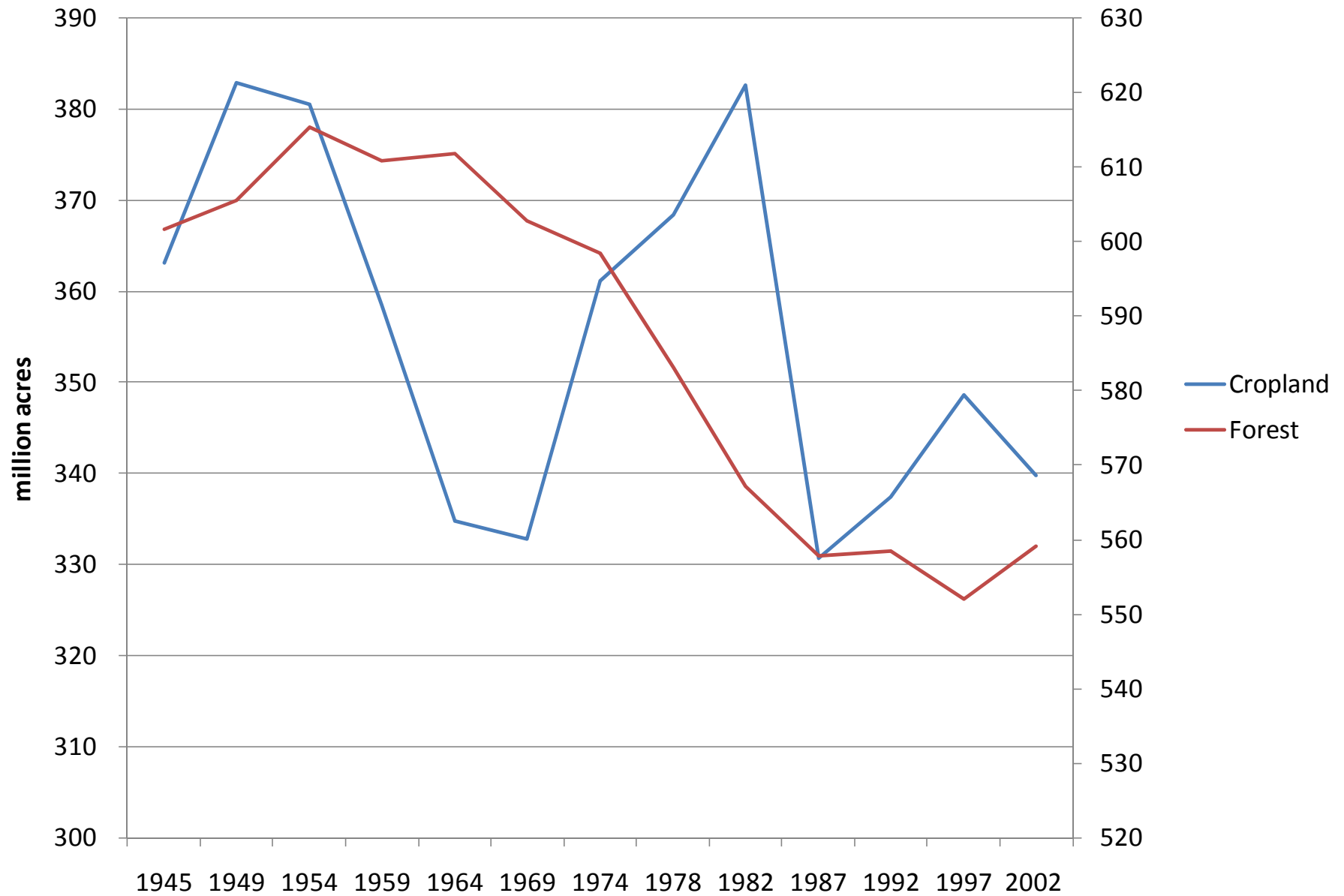


## Cropland and Pasture since 1945

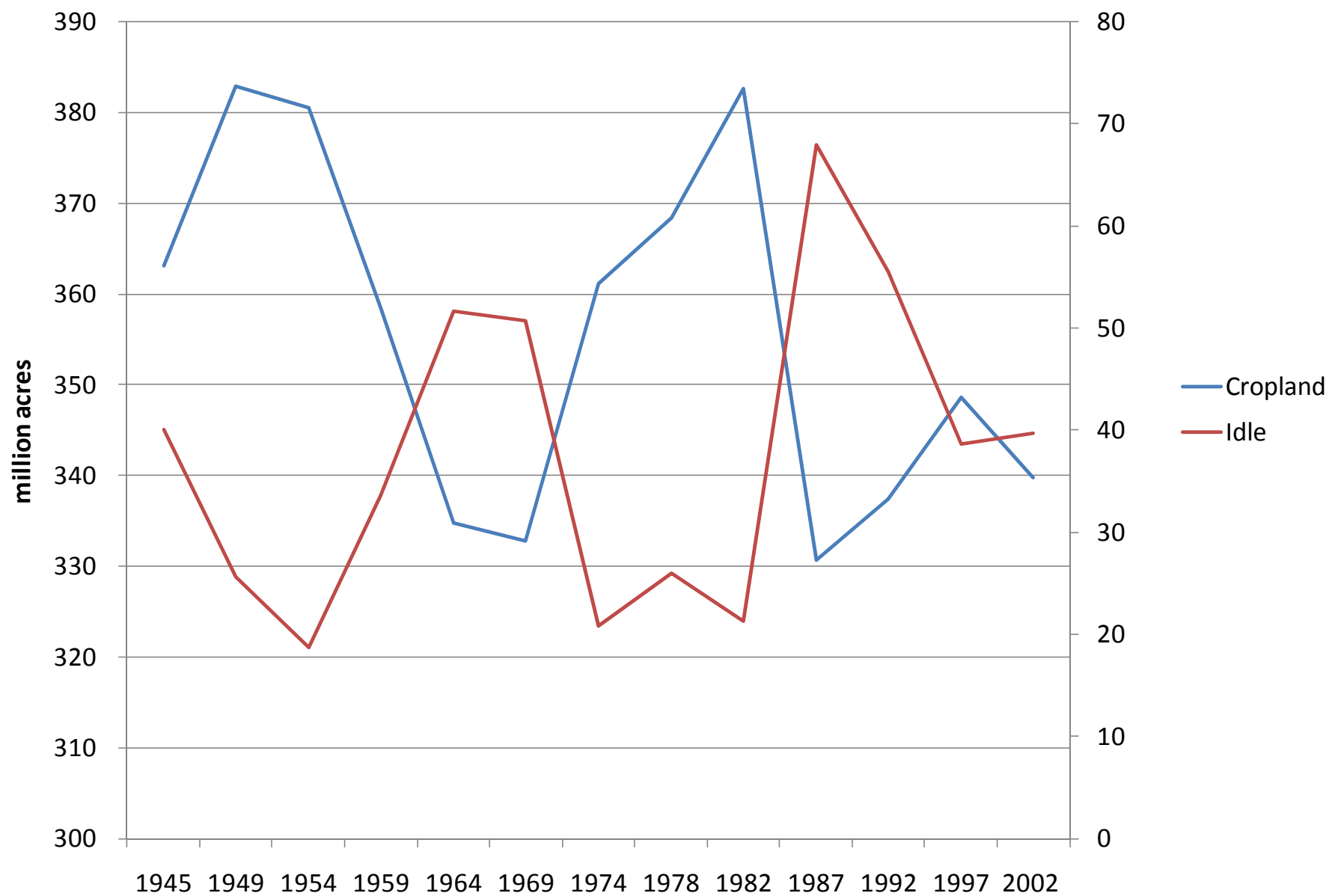




## Cropland and Forest since 1945



## Cropland and Idle Cropland since 1945



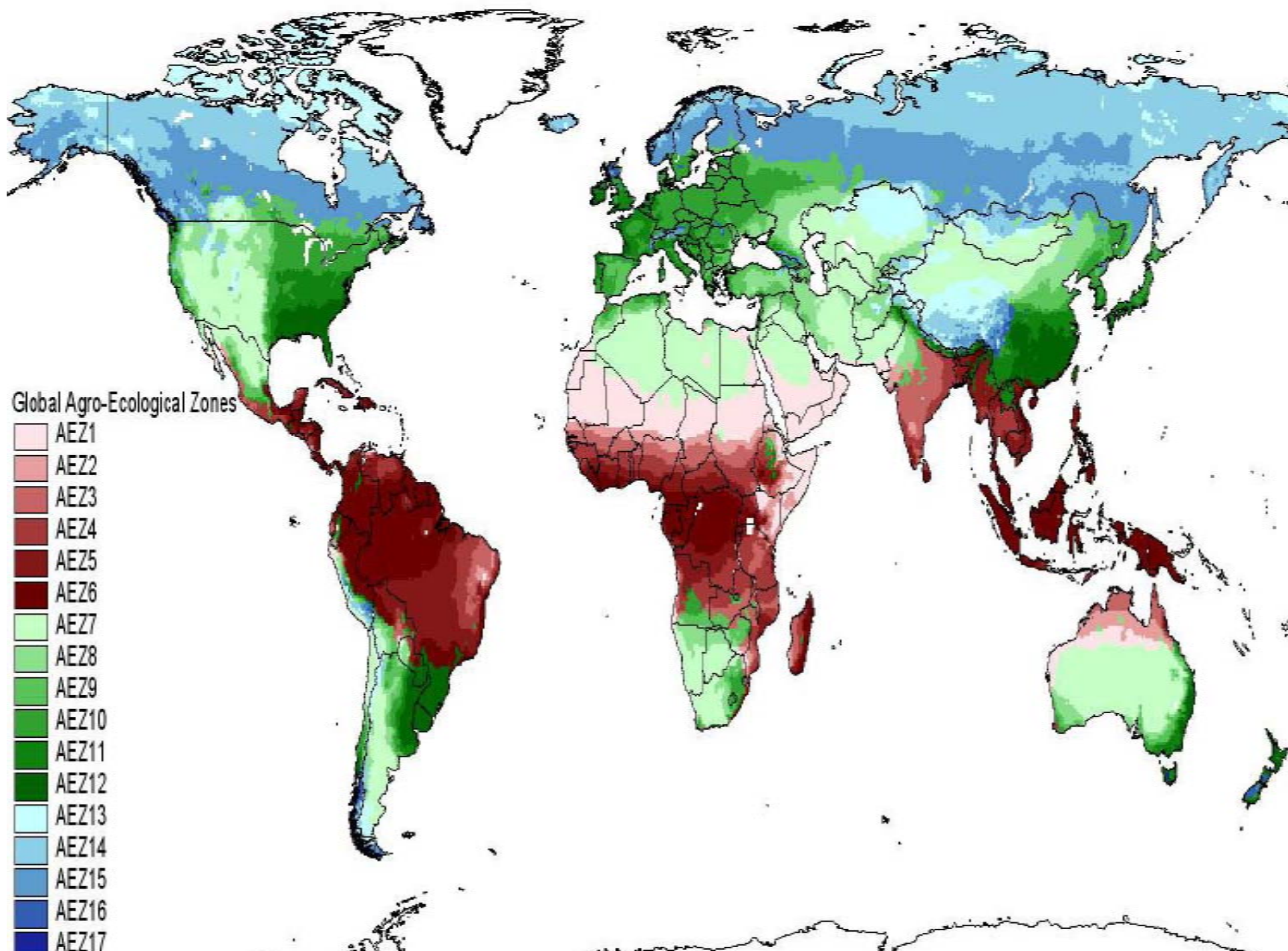
# Land Use Elasticity Logic

- Purpose of using GTAP is to measure the change in land use due to a crop price increase
- The more cropland-constrained a region is, the less a region will readily (one to five years) respond to crop price signals
  - Need to know the amount of idle cropland available
- Need to know the share of potential cropland not being used to find longer-run elasticities
  - If cropland comprises a large share of potential cropland, then the region will respond little in any time horizon
- Conversion of pasture to crops will occur more readily than conversion of forests to crops
  - Elasticity of pasture land with respect to crop prices more elastic (more negative) than elasticity of forest land with respect to crop price due to conversion costs and less irreversibility

# GTAP Framework

- Elasticity of land use determined by share of revenue generated in a region
  - The greater the share of revenue accounted for by crops, the less will be a region's cropland response to crop prices
- Mature land use
  - Share of revenue likely a good estimate of land constraints
  - If crops in a region have a large land share, then they likely have a large revenue share
- Immature land use (Brazil)
  - In crop expansion regions, share of crops could be large because there are few markets for forest and animal products
  - Could be understating elasticity
- No physical land constraints or explicit considerations of potential supply of cropland

An Example: AEZ 11 in the U.S.  
(includes Illinois and Indiana)



## An Example: AEZ 11 in the U.S. (includes Illinois and Indiana)

- Share of revenue from crops = 87%
- With CET parameter = -.2,

$$\varepsilon_{crop,crop} = 0.2(1 - 0.87) = 0.025$$

- Share of revenue from pasture and forests equal 3% and 10%.

$$\varepsilon_{pasture,pasture} = 0.2(1 - .03) = 0.195$$

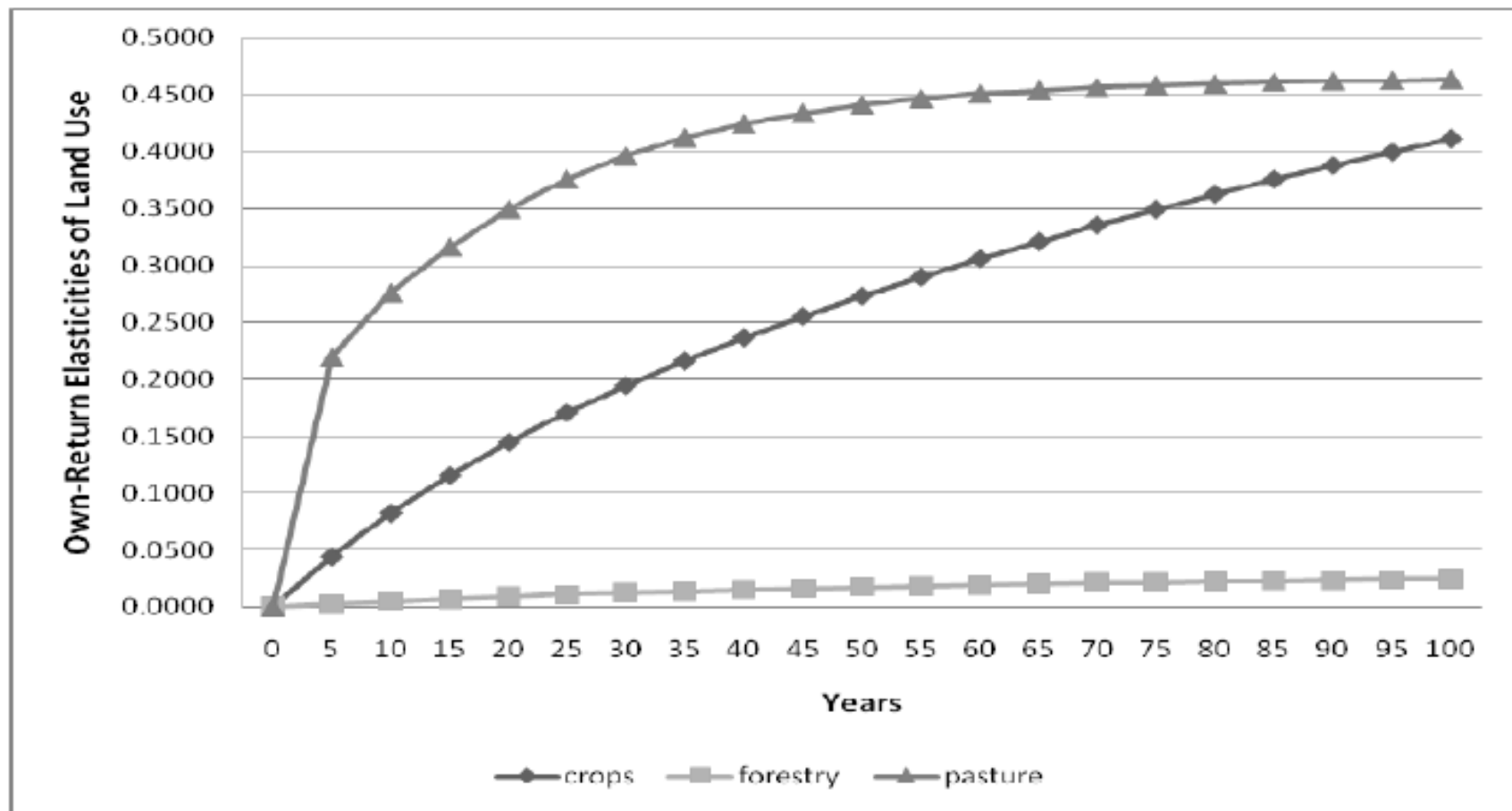
$$\varepsilon_{forest,forest} = 0.2(1 - .14) = 0.180$$

# Seemingly Reasonable

- Because forest and pasture are much less important in terms of revenue and aggregate land use, it would seem that they would be more responsive than crops to a change in own returns
- But the AEZ 11 elasticity for forest is much higher and elasticity for pasture much lower than the time series (not cross section) evidence suggests



## U.S. Own Return Elasticities Simulated by Ahmed, Hertel, and Lubowski 2008



**Figure 2: Own-Return Elasticities of Land Use at  $t$  for Use  $i$**

**Source: Authors' Simulations**

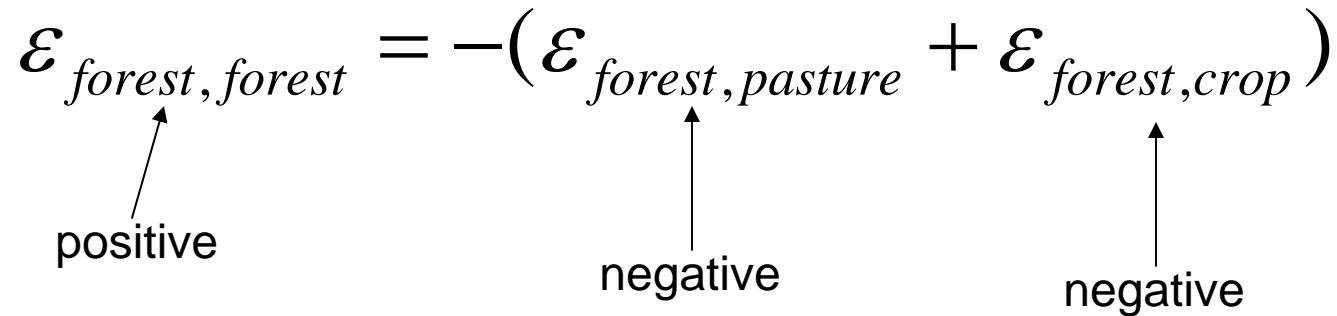
# Does it Matter?

- CARB should not really be interested in own return elasticities from pasture and forests unless they impact the change in pasture and forest due to a crop price increase.
- But inelastic own returns for forest require quite inelastic response of forests to a change in crop prices

# Implications of Too-Elastic Own Returns from Forest

$$\varepsilon_{forest,forest} = -(\varepsilon_{forest,pasture} + \varepsilon_{forest,crop})$$

positive                      negative                      negative



If forest own return elasticity = 0.18, then the elasticity of forest land with respect to crop returns can range between 0.0 and -0.18

If forest own return elasticity = 0.005, then the elasticity of forest land with respect to crop returns can range between 0.0 and -0.005.

# GTAP Cross Price Elasticities in AEZ 11

- What is the %change in pasture (forest) due to a 1% increase in crop returns?

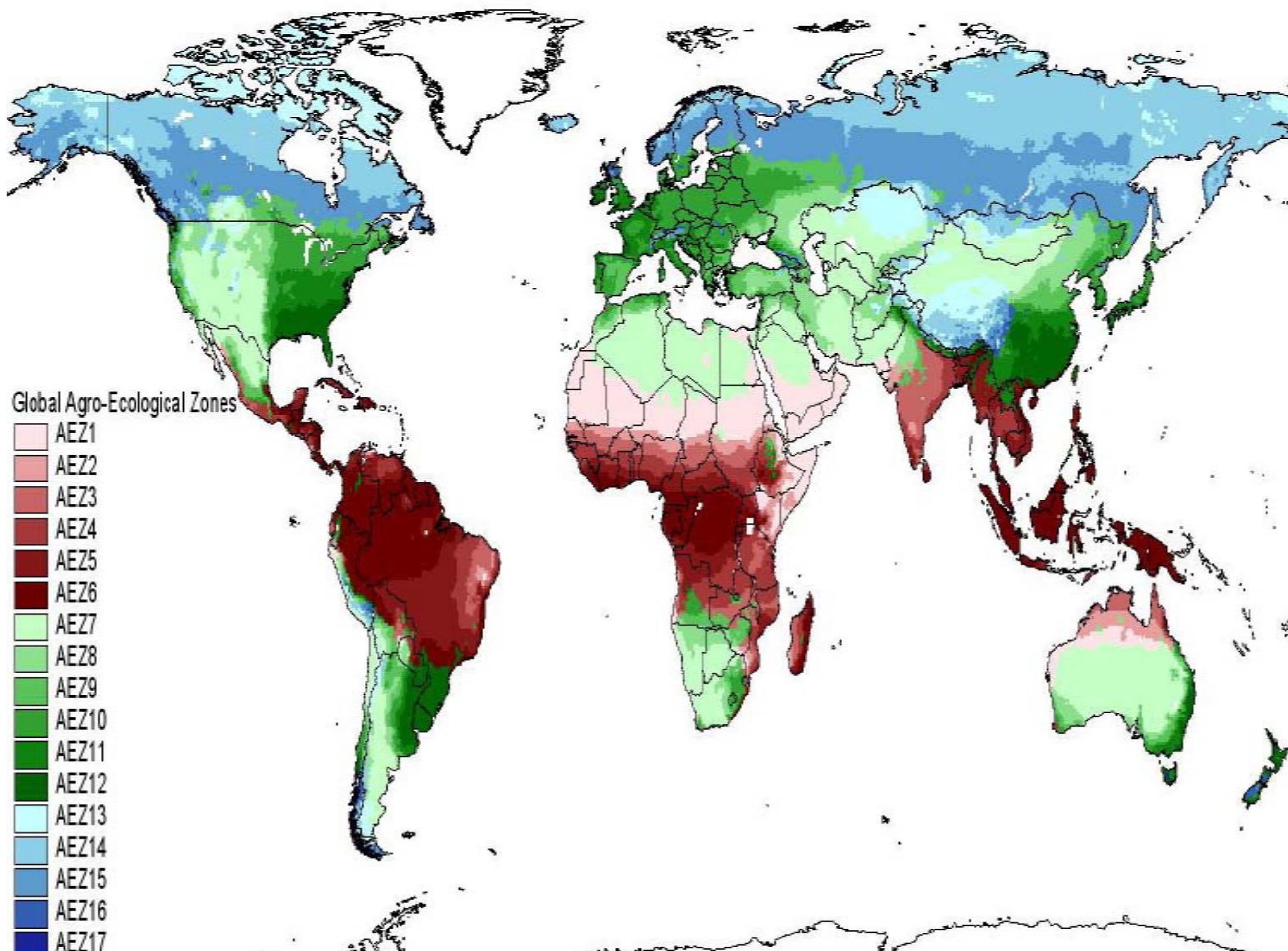
$$\varepsilon_{pasture,crop} = \varepsilon_{forest,crop} = -0.2 * .87 = -0.174$$

- A 10% increase in crop returns decreases both pasture and forest lands by 1.74%.
- This responsiveness is 35 times as great as the maximum responsiveness using the estimated elasticity.

# Are Current GTAP Forest Elasticities Credible?

- The 15 year response to an increase in forest returns is quite inelastic
- Higher forest elasticities found in the literature measure the very long run response to relative returns.
  - A long-run sorting out of what land will be in crops and what land will remain in forests
- What length of time is the analysis aimed at?
- If very long run, uncertainties explode
  - How can crop prices stay high in the long run?

# Brazilian Example: AEZ 5 and 6 (W.C. Cerrados and Amazon)

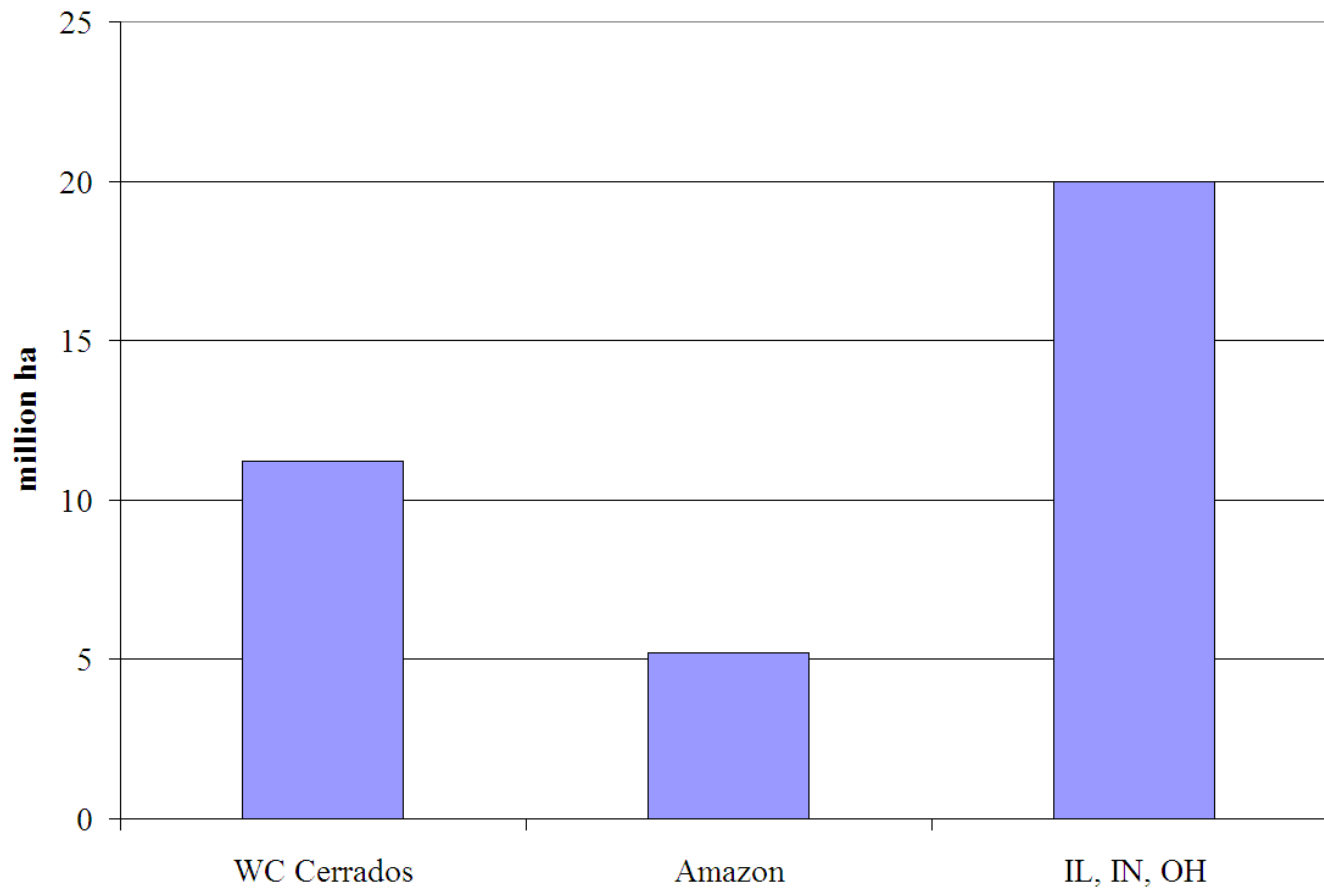


## Brazilian Example: AEZ 5 and 6 (W.C. Cerrados and Amazon)

- Share of crop revenue = 0.60, 0.55
  - Crop elasticity = 0.08, 0.085
- Cross price elasticities of forests and pasture with respect to crop returns
  - 0.12 in Cerrados, -0.11 in Amazon
- Forests and pasture are less responsive to crop returns in main Brazilian expansion areas than in Illinois and Indiana

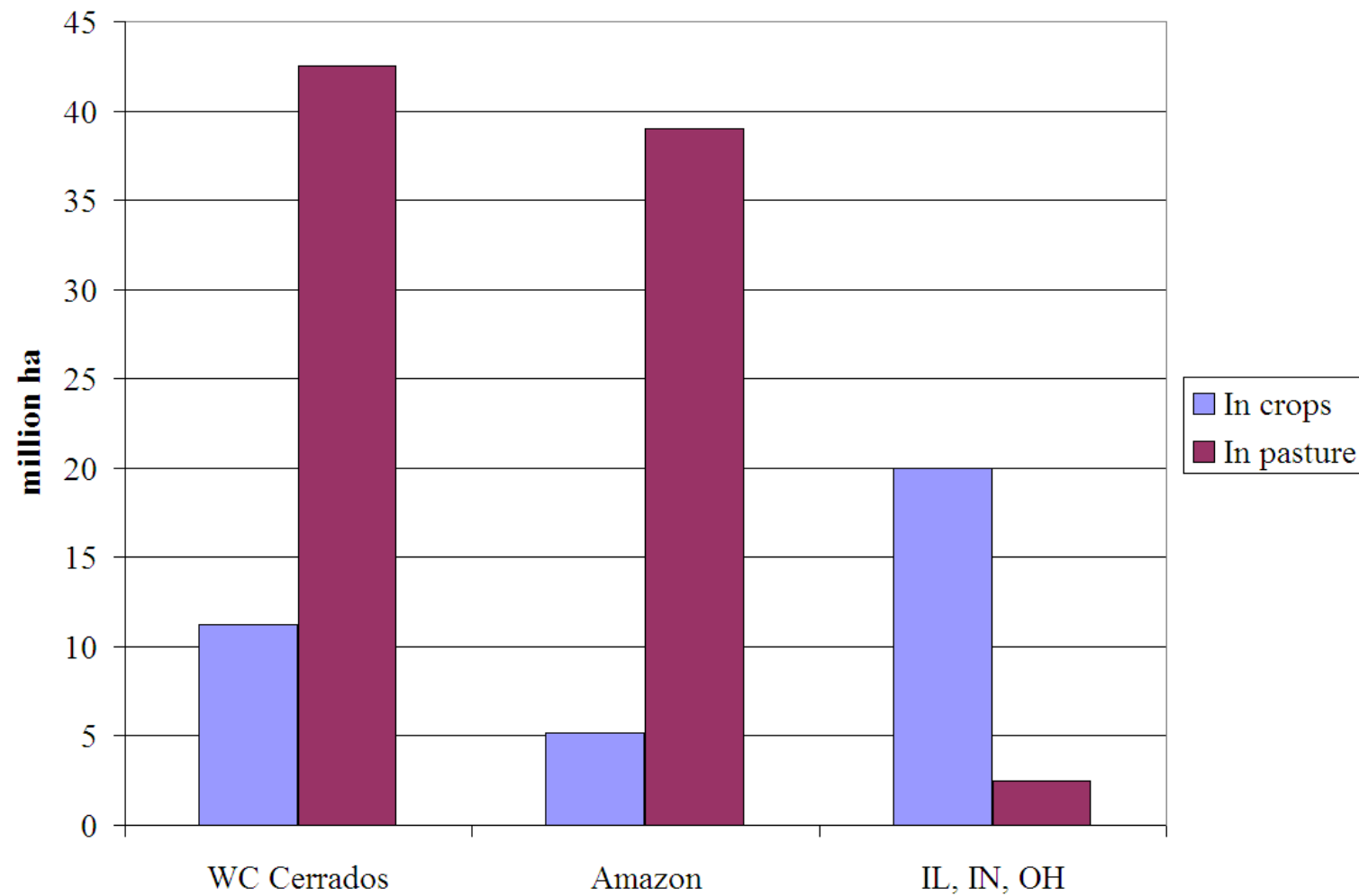


# Land in Crops



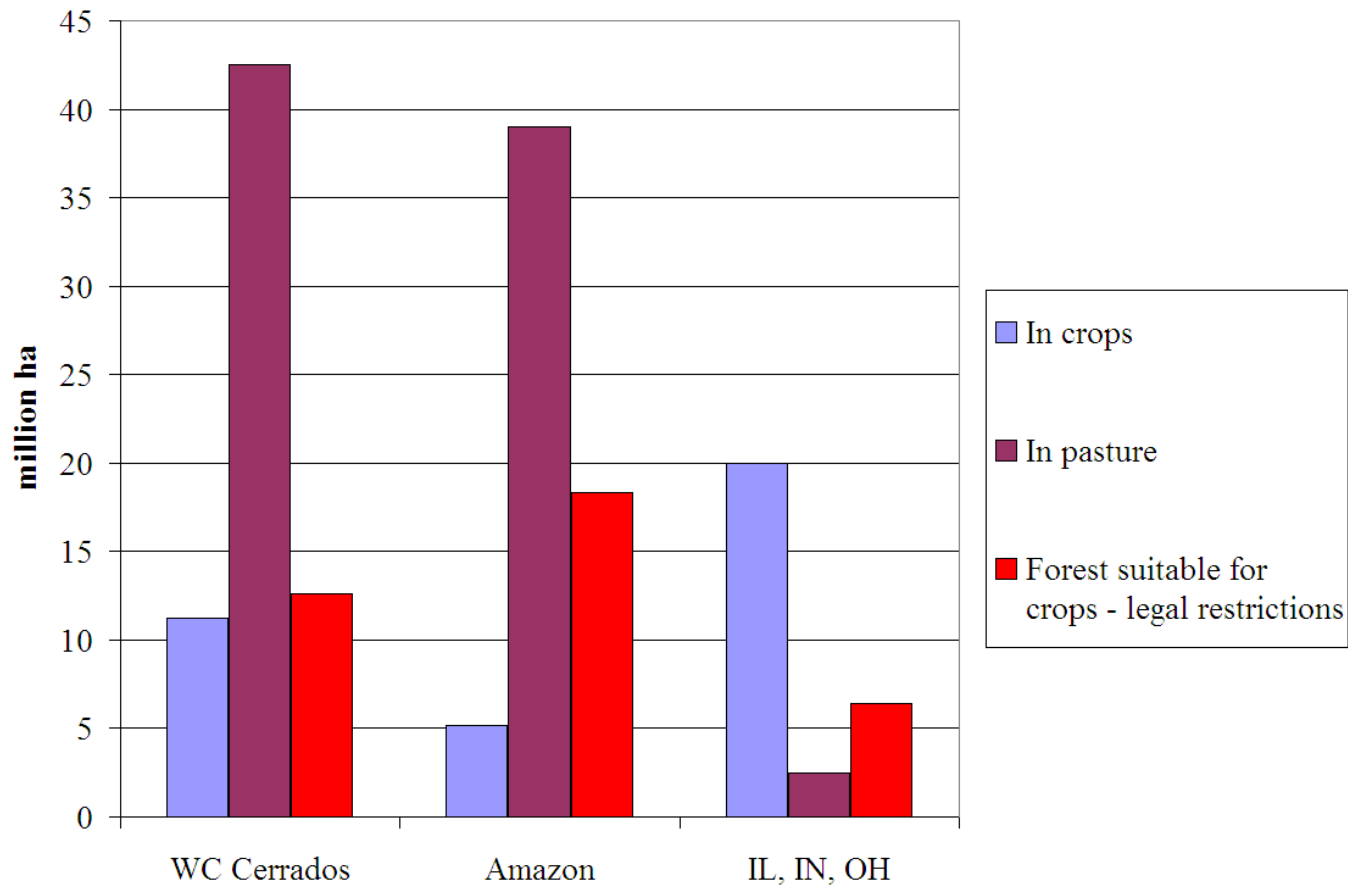
Source: FAPRI Brazil model (BLUM) and U.S. Census of Agriculture

# Land in Crops and Pasture



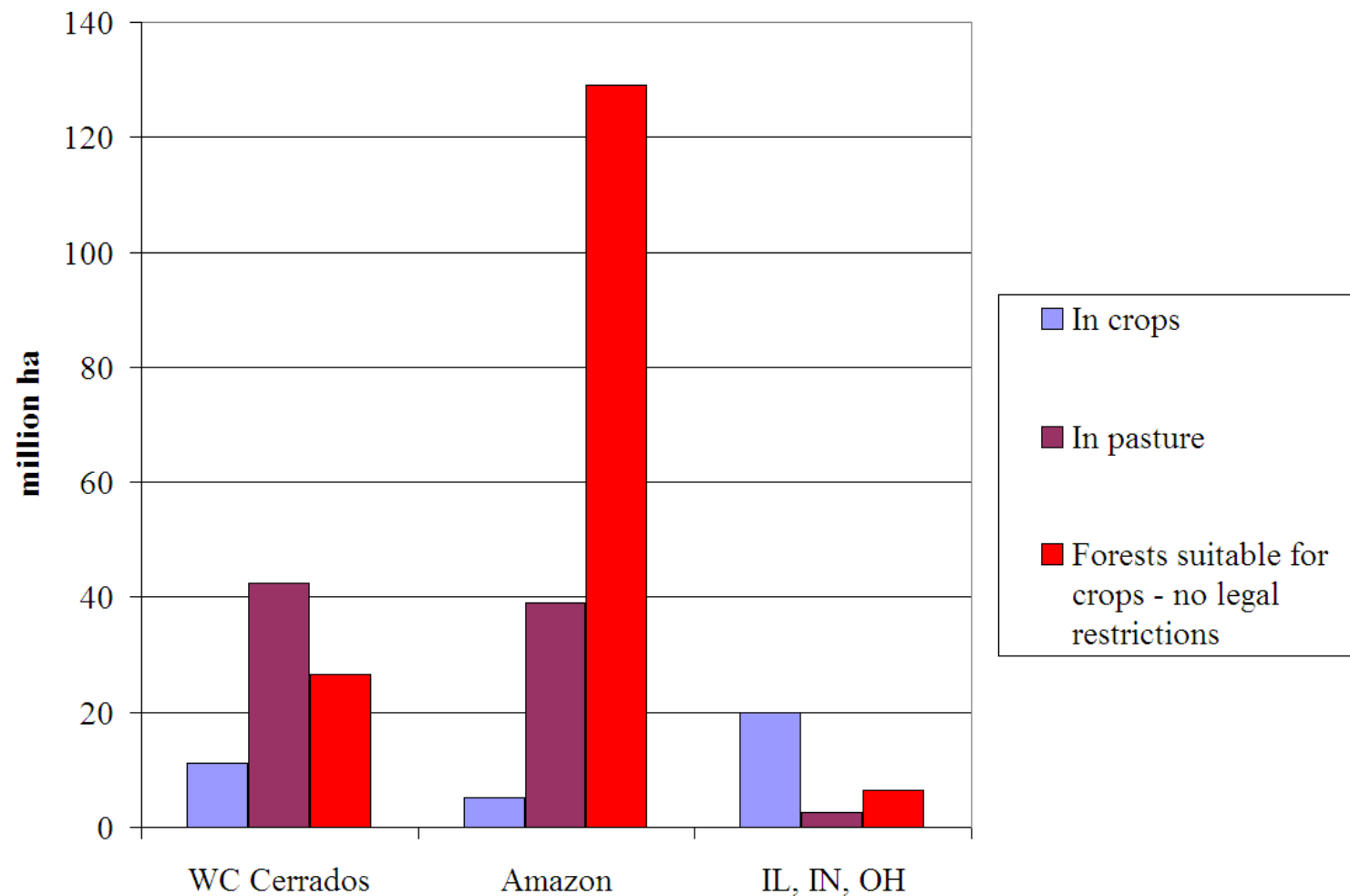
Source: FAPRI Brazil model , U.S. Census of Agriculture, and UFMG.

# Land in Crops, Pasture, and Forests



Source: FAPRI Brazil model , U.S. Census of Agriculture, UFMG, and ESALQ. Assumes all forested land in Ohio, Indiana, and Illinois is suitable for crops.

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# First Finding and Recommendation

- To be credible, GTAP needs to be improved to allow greater flexibility in elasticities
  - Should integrate land potentially available and suitable for crops to be reflected in the elasticities
  - Need to account for irreversibilities (sunk costs) in cutting down or planting forests for medium term elasticities

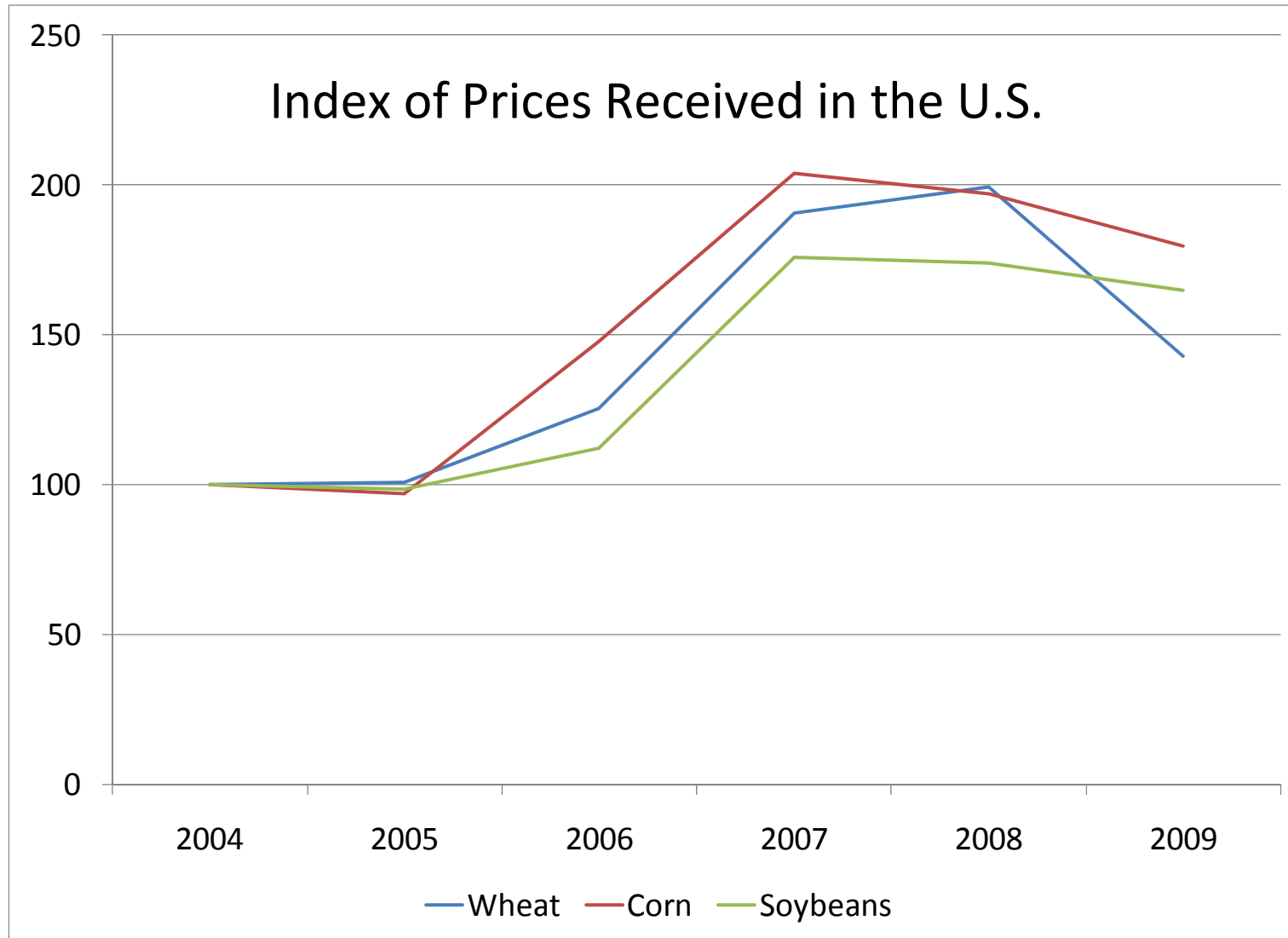
# Elasticity of Crop Yields with Respect to Area Expansion

- Seems to make sense that land not in production is less productive than land in production: CARB used 0.5 to 0.75 in their runs
  - But in undeveloped countries, productive land may not yet be converted because of transportation costs or conversion costs
  - In developed countries, depends on the amount of new land that is being planted
  - If very few additional acres are being planted, then perhaps little to no yield loss

# Estimated Values

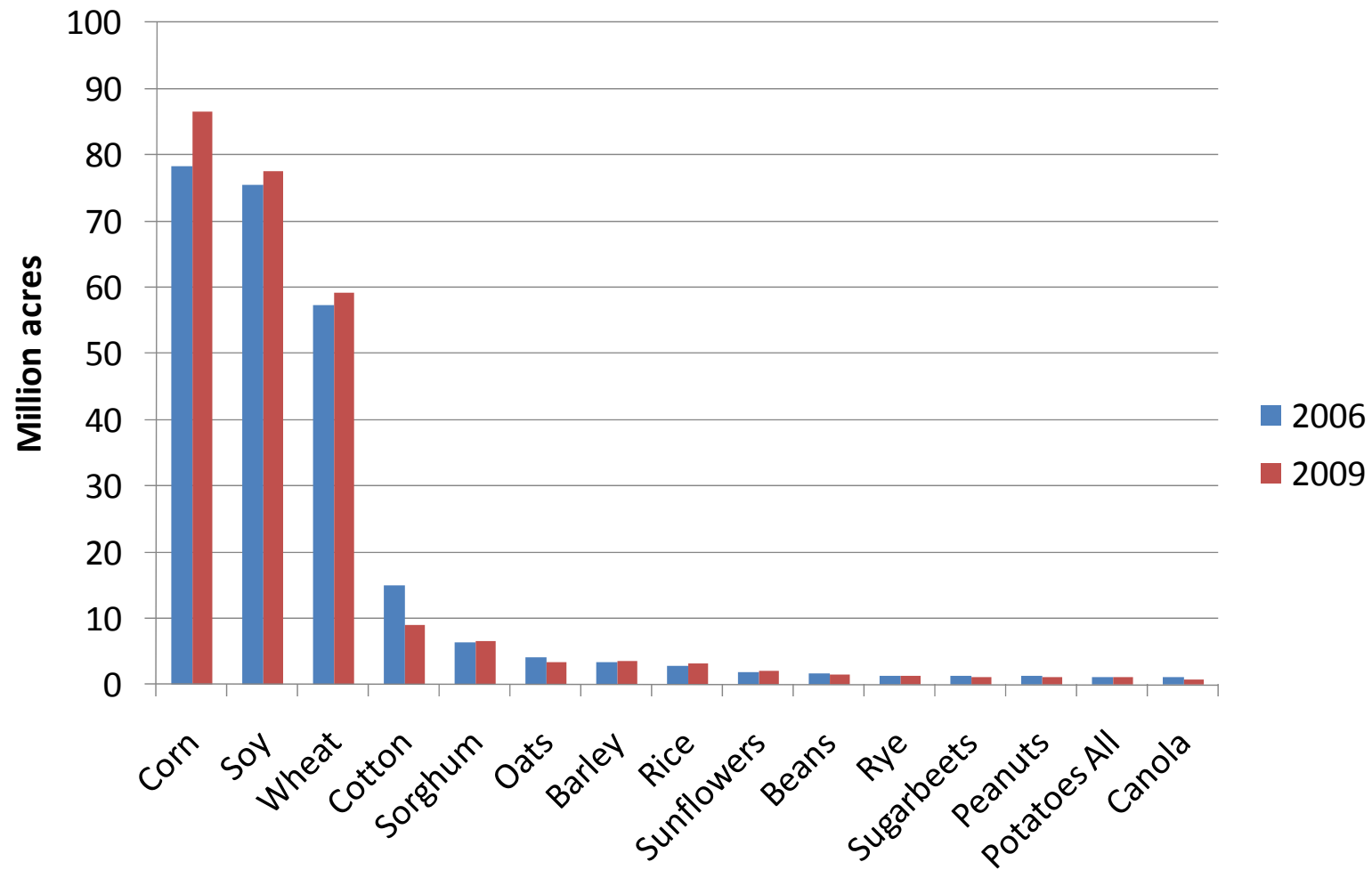
- Tyner et al (2010)
  - U.S. ratios vary between 0.51 and 1.0
  - Brazil ratios vary between 0.89 and 1.0
- Babcock and Carriquiry (2010)
  - Cannot reject the hypothesis that Brazilian soybean yields on new land are equal to yields on old land

# New Estimates for the U.S.

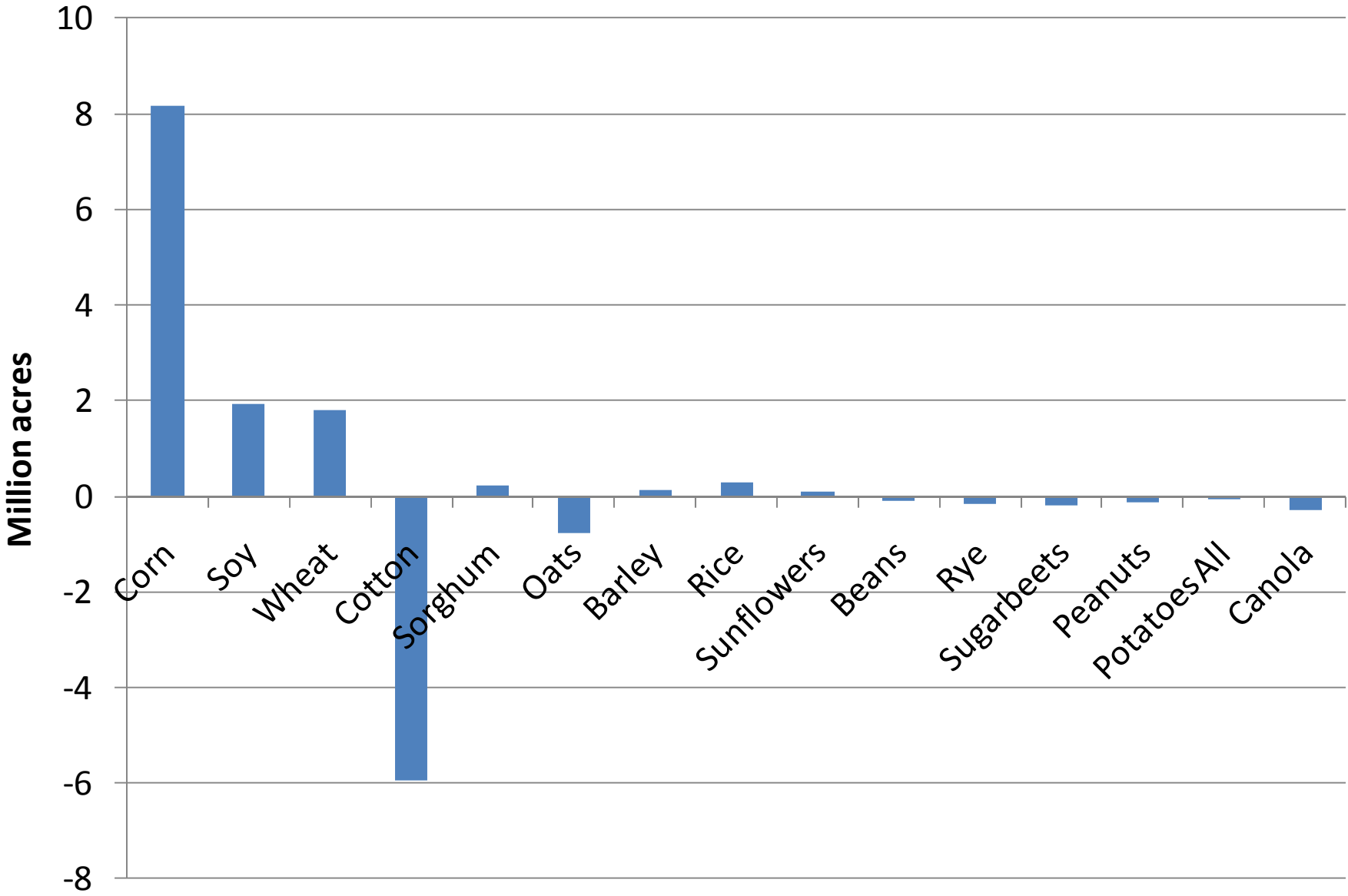




# Important U.S. Crops



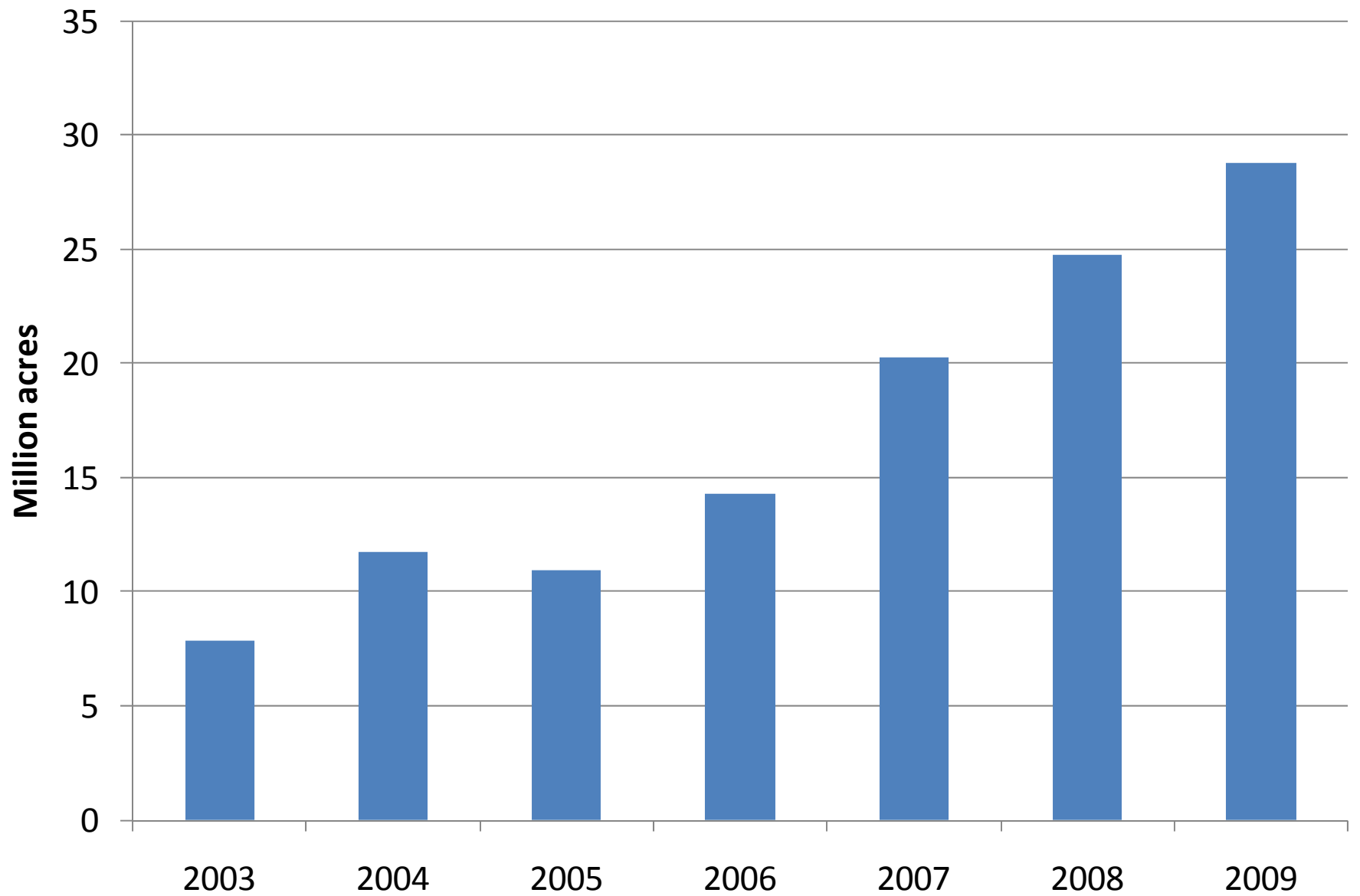
# Change in Planted Acres 2009 from 2006



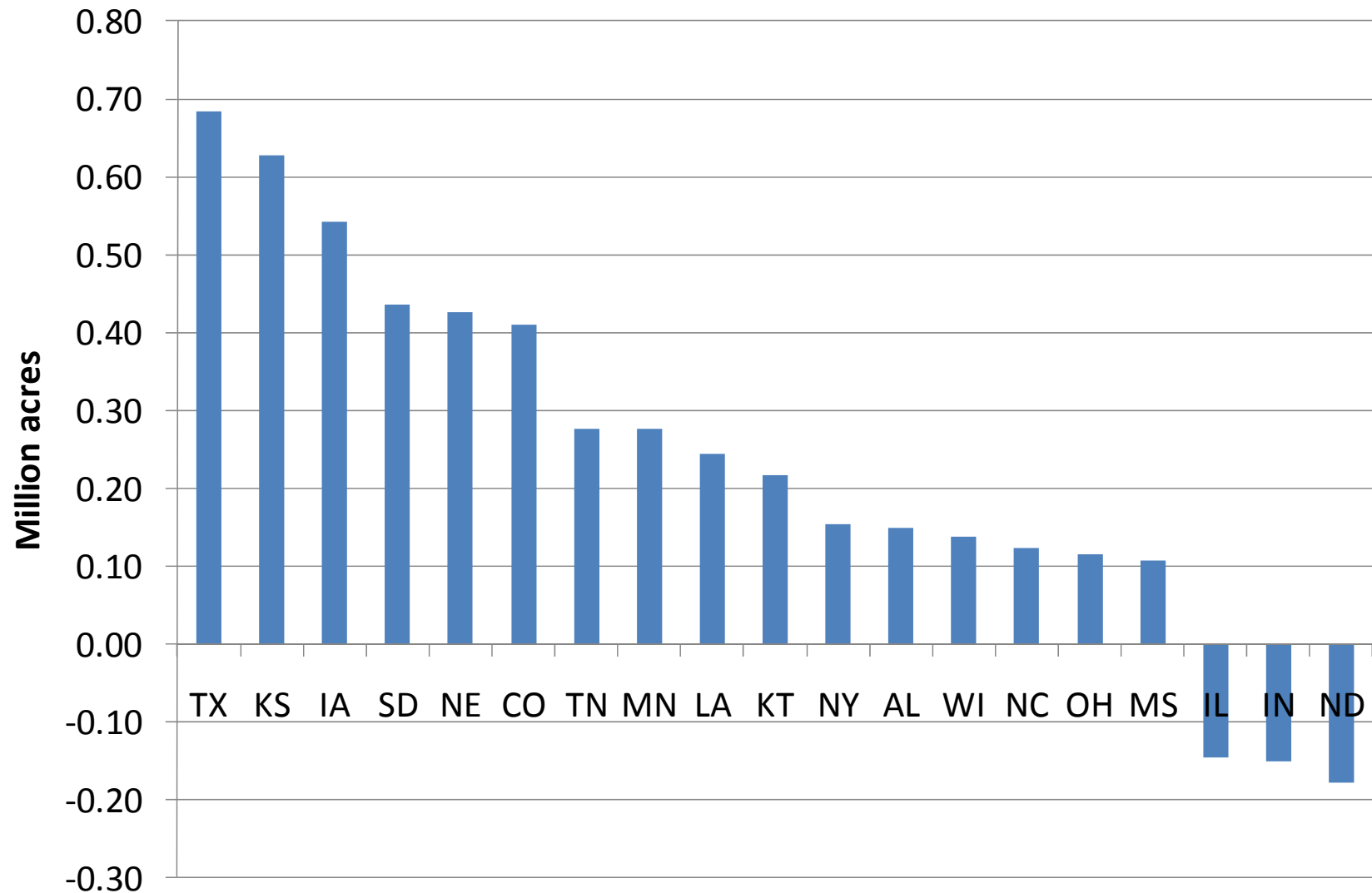
# U.S. Crop Acreage is Inelastic

- A 50% increase in expected farmer returns from growing principal crops led to a 1.7% increase in acreage from 2006 to 2009 (about 4 million acres)
- Elasticity of U.S. crop acreage equals 0.033.

## U.S. Corn Ethanol Production Expressed in Acres

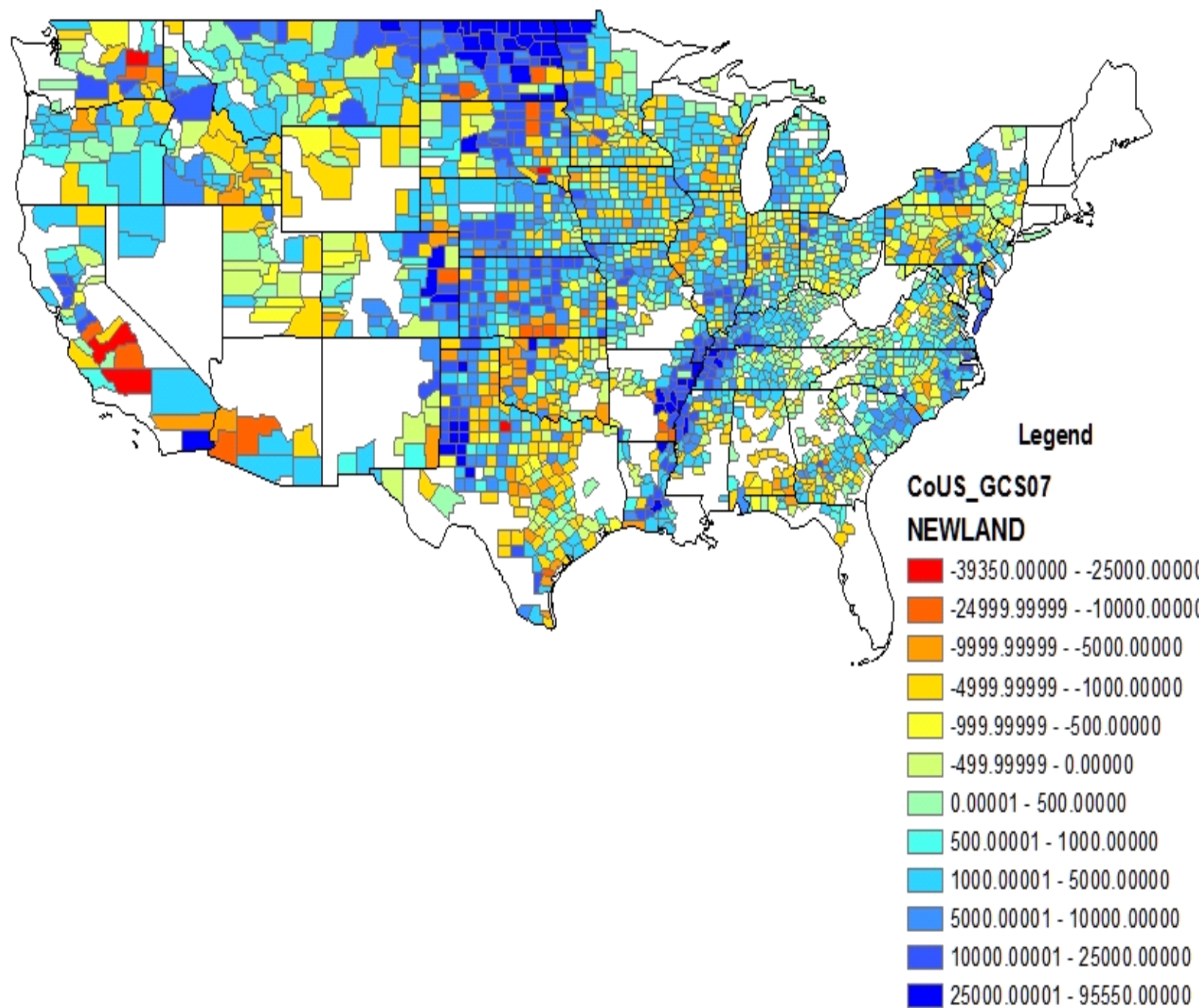


# Where did Land Use Change?



# Method Used

- Use county level data to estimate where cropland expanded (15 top U.S. crops)
- Use county trend yields to approximate the yield in each county for each crop
- Compare the average yield in counties that expanded to average yields in the base period (2006)



**Table 1. Results**

Commodity	No Expansion Yield	Yield in Expansion Counties	Ratio
Wheat (bu)	40.5	49.8	1.23
Potatoes (cwt)	426.9	519.8	1.22
Peanuts (lbs)	3244.8	3622.6	1.12
Barley (bu)	60.3	63.4	1.05
Canola (lbs)	1537.3	1567.3	1.02
Rice (pounds)	7141.3	7014.0	0.98
Cotton (lbs)	914.3	886.4	0.97
Corn (bu)	158.7	151.4	0.95
Rye (bu)	19.3	18.0	0.93
Beans (lbs)	1726.7	1584.4	0.92
Sugarbeets (tons)	26.8	24.0	0.90
Sorghum(bu)	70.8	60.8	0.86
Oats (bu)	62.3	52.6	0.84
Soybeans (bu)	43.5	35.7	0.82



# Findings and Recommendation II

- Shifting of crops is much more important than expansion of crop land in the U.S.
- No evidence of large yield changes due to cropland expansion
- No strong evidence supporting significantly lower crop yields on new land